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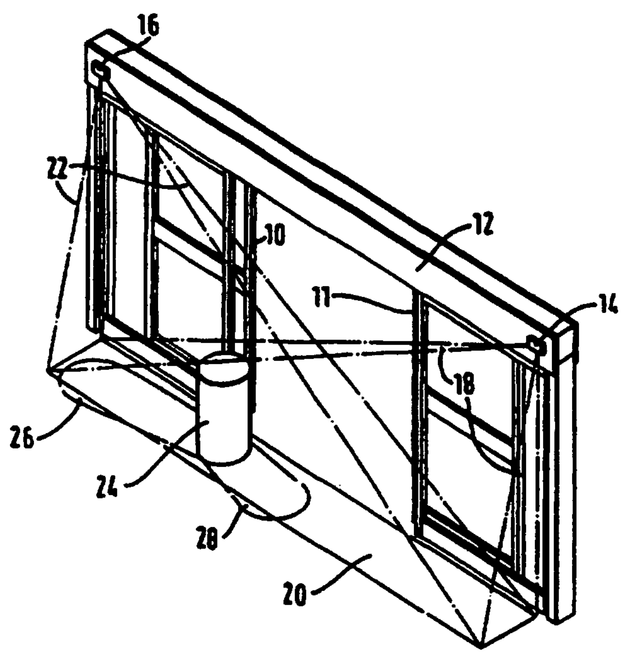
(54) **Proximity detectors**

(57) A proximity detection system for detecting the presence of an object in a given zone or area comprises a transmitter (14) arranged to illuminate that zone (20) and a receiver (16) arranged to receive illumination reflected from that zone (20). The transmitter (14) and detector (16) are arranged such that the presence of an object (24) in the zone (20) results in a decrease in the strength of the signal reflected to the receiver (16). This is because the object (24) casts a shadow (26) in the illumination from the transmitter (14) and the strength of the receiver signal is further reduced by the object (24) preventing transmitted light reflected from a second area (28) from reaching the receiver (16). In one embodiment polarising means are provided to polarise the received and transmitted illumination in substantially orthogonal planes.

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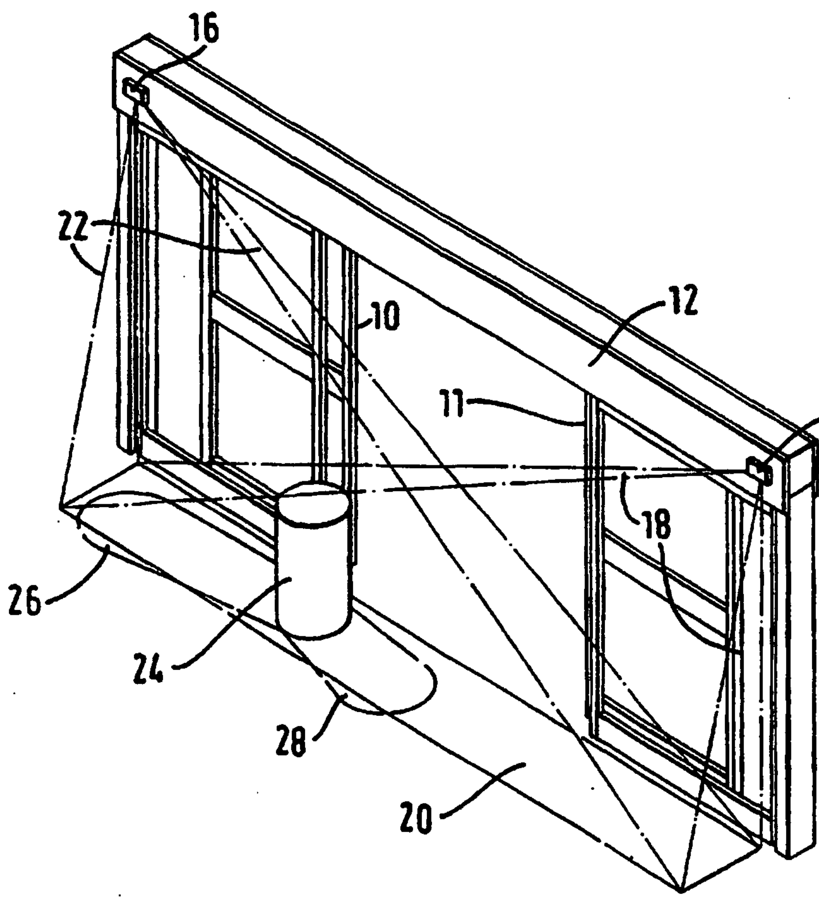
(54) Title: PROXIMITY DETECTORS

(57) Abstract

A proximity detection system for detecting the presence of an object in a given zone or area comprises a transmitter (14) arranged to illuminate that zone (20) and a receiver (16) arranged to receive illumination reflected from that zone (20). The transmitter (14) and detector (16) are arranged such that the presence of an object (24) in the zone (20) results in a decrease in the strength of the signal reflected to the receiver (16). This is because the object (24) casts a shadow (26) in the illumination from the transmitter (14) and the strength of the receiver signal is further reduced by the object (24) preventing transmitted light reflected from a second area (28) from reaching the receiver (16). In one embodiment polarising means are provided to polarise the received and transmitted illumination in substantially orthogonal planes.



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PROXIMITY DETECTORS

This invention relates to proximity detectors which detect the presence of an object, typically a human being, in a given zone or area. The invention has particular, but by no means exclusive, application to detecting the presence of a human being in the vicinity of automatically operable doors.

There are a number of safety problems associated with automatically operable doors which are in use in large numbers within many public buildings. The doors can be the sliding type, swing type, rotary type, or bi-folding type. The main difficulty concerns the use of microwave motion detectors to actuate the automatic door operator to allow the passage of traffic through the door. Whilst such a motion detector is adquate as an actuator it is not possible to detect a totally stationary object with this kind of motion detector. This can present a safety hazard in that if a person is close to the automatic door and the doors are in an open position and if the movement of that person is insufficient to trigger the motion detector then it is possible that the doors may close possibly startling, crushing or trapping the person between the doors. To alleviate this problem it has been common to use a photoelectric detector which is mounted on the frame of the door and projects a pencil-thin beam across the face of the door. Whilst this beam is sufficient to detect the presence of a person actually between the doors, since it is necessary to break the beam, it is not possible to detect a person in very close proximity to the door

when a person is in such a position so as not to break the beam. The problem can be further accentuated if that person is using a walking frame for example. The walking frame may not break the beam and the doors may therefore close trapping the walking frame which can destabilise the person who is using the frame. It is therefore highly desirable to provide a presence detector which works within, for example, 16 inches either side of the door. The proximity detector should provide a sensitive area within which the presence of a person, whether stationary or not, will cause the doors to remain in the open position until the zone is cleared on both sides.

A number of devices have been proposed and one example is described in Stanley Patent No. 4823010. This describes a proximity detector for use with automatic sliding doors. Whilst this detector does provide a measure of increased safety to the users of automatic doors it does not however provide detection coverage all the way to the floor. Its sensitivity is also dependent somewhat on the reflectivity of the floor over which the detector is positioned. The detector is also very sensitive to the reflectivity of the object, it being less sensitive to less reflective objects. This detector is also insensitive when the area of the object to be detected is very small, such as in the case of small adults or small children, wherein particular the area presented to the detector (that is the plan view of the person) is a small area. This can be further accentuated if the hair colouring is dark or the clothing is dark.

In addition the Stanley device is rendered inoperative when the doors have started to close. This is necessary because the plane of the door intersects the sensitive area.

Prior art detectors have been based on a number of different physical phenomena and use a number of detection media, e.g. microwave, ultrasonic, passive infra-red and active infra-red. For short range use (20 feet or less) active infra-red offers a number of advantages not least of which is small-sized, low cost and relatively high noise immunity. When using infra-red it is common to employ a retro-reflective arrangement, whereby infra-red radiation from the transmitter is reflected off the surface of the object to be detected and is then measured by the receiver. When the received signal is greater than a predetermined theshold the control signal is given to indicate that an object has been detected. When using this kind of detector to detect people, for example, a major disadvantage becomes apparent in that the detection range of the detector is dependent to a large degree on the reflectivity (at the transmitted wavelength) of the object to be detected. In the case of collision avoidance systems, which may be associated with moving vehicles or machinery such as automatic doors, this can be a major disadvantage. As a simple example consider the case where the minimum detection range is say 2 feet. It would therefore be necessary to set the sensitivity of the detector to a level that ensures that the least reflective object (e.g. matt black) is detected at a range of 2 feet. Such a sensitivity point would mean that a highly reflective object (say 10 times more

reflective than matt black) would be detected at over 6 feet. This can in many cases present severe operational difficulties.

In the above it has been assumed that the projected illumination from the transmitter forms an illuminated pool smaller than the object to be detected. Provided that this condition is met increases in the surface area of the object to be detected will not increase the detection range of the device. If the above condition is not met, however, as will be the case whenever the detection field is required to extend far beyond the dimensions of the object to be detected, then the detection range will be affected by the surface area of the reflecting object.

U.S. Patent No. 4,973,837 describes a proximity detector arrangement that suffers to some extent from this undesirable characteristic, although some methods of improvement are described. The document describes a proximity detector that is mounted at a height of typically 7 feet 6 inches and projects a detection zone downwards towards the floor, the dimensions of that detection zone being defined by a mask. For simplicity this type of detector will be referred to as being retro-reflective and having a geometrically determined range. Whilst this type of retro-reflective detector does accurately provide a detection field that is largely independent of the object's size and reflectivity, this immunity is achieved by providing a high degree of sensitivity within the geometrically determined range. The sensitivity needs to be high enough to detect the

smallest expected surface area having the least reflective surface at the furthest point of the detection field. There are some practical disadvantages of having such a high degree of sensitivity since the detector, in the absence of a person is looking at the illuminated portion of the floor and becomes sensitive to relatively small changes in the surface reflectivity of that floor. Such changes can be brought about by, for example, the displacement of a floor mat or the wetting of the floor.

It is an object of the present invention to provide a proximity detector that has an accurately defined range and is largely immune to variations in the object's surface area and reflectivity whilst also being relatively insensitive to temporal changes in the floor reflectivity or similar surfaces (e.g. ceiling wall etc. if the radiation is reflected from them). The present detector can be used as a presence detector, a motion detector or both.

According to one aspect of the present invention there is provided a proximity detector comprising a transmitter for transmitting a beam of radiation into a preselected area or zone, a receiver for receiving radiation from that zone, the transmitter and receiver being spaced apart and so located relative to said zone that the transmitter transmits a beam of radiation of predetermined shape into the area from where it is reflected into the receiver, the relative dispositions of the transmitter and receiver being such that when an object is present in the zone a shadow is effectively cast on either

side of the object to thereby cause a fall in the level of reflected radiation received at the receiver.

The detector may include control circuitry responsive to the received signals for providing actuating signals for controlling, for example, automatically operable doors. The control circuitry may include any one or more of the following. Means for avoiding interference between a number of similar detectors operating in close proximity to one another. Means providing relatively high immunity to interfering signals such as broad band infra-red emission from fluorescent lighting, mains hum, radio signals and intense sunlight. Means for providing high immunity to changes in the effective sensitivity of silicon photo diodes due to high intensity ambient light. Means for providing high immunity against temperature drift of receivers and transmitters. Means for providing automatic compensation for background reflectivity levels. Temperal variations in background reflectivity levels. A means for providing an automatically initiable rapid reset if detection of an object is continuous for greater than a predetermined period of time. Means for providing an audible or visual announcement prior to the rapid reset facility.

A feature of the present detector is that it is relatively insensitive to variations in area, reflectivity or colour of the object and hence represents an enhancement on the prior art. It can be used in addition to known motion detectors or can

itself be used in association with appropriate control circuity to provide the motion detection.

Another aspect of the present invention relates to the operation of a proximity detector in situations where the reflecting surface, e.g. a floor, is damp or wet. Such condition can produce specular reflections and this can affect the operation of the detector. I have found that the problem of specular reflection can be alleviated by using polarising means for polarising the radiation.

Thus according to another aspect of the invention there is provided a proximity detector of the type in which a transmitter transmits radiation into zone or zones and a receiver detects radiation received from the zone to provide actuating signals for actuating apparatus such as automatically operable doors, wherein a polarising means for polarising the radiation is associated with at least one of the transmitter and receiver. The polarising means is preferably associated with both the transmitter and the receiving and the polarising means is also preferably arranged to function as a crossed polariser.

The invention will be described now by way of example only, with particular reference to the accompanying drawings. In the drawings:

Figure 1 is a schematic view showing automatically operable doors equipped with a proximity detector in accordance with the present invention;

Figures 2A and 2B show control circuitry for use with the detector of Figure 1;

Figure 3 is a schematic view showing an alternative form of proximity detector, and

Figures 4 and 5 illustrate the operation of the detector.

Referring to Figure 1 a pair of automatically operable sliding doors (10, 11) are mounted in a frame (12). A proximity detector has a transmitter (14) which is mounted at one top corner of the frame (12) and a receiver (16) which is mounted at the opposite top corner. The transmitter (14) transmits a beam (18) of radiation, e.g. infra-red or near infra-red into a narrow zone (20) and the receiver can receive radiation reflected from that zone as shown by the reception beam (22). A similar transmitter and receiver arrangement is mounted on the opposite side of the door frame. The transmitter and/or receiver can have their transmitting or receiving field constrained to form the beam shapes shown in Figure 1 by means of a masking arrangement of the type described in US-A-4973837.

When an object as exemplified by the cylinder (24) in Figure 1 is present in the zone (20) a shadow (26, 28) is cast on either side of that object. Shadow (26) is caused by the object obstructing radiation transmitted from the transmitter and shadow (28) is caused by the object obstructing radiation reflected from the zone (20). It will be

seen that the size of the shadow is significantly greater than the upper surface of the object.

In this way the increase in the received signal strength due to transmitted energy reflected from the object's horizontal surface is very small compared with the decrease in received signals strength caused by the object's shadow as a result of the vertical surface area it presents to the transmitted wave front from the transmitter unit.

Besides the shading effect, the receiver has a portion of its field of view obscured by the object causing a further reduction in the received signal by virtue of the presence of the object within the sensitive area. Hence the presence of the object results in a significant decrease in the received signal.

It should be noted that the area of the shadow and the area of the obscured region is a function of the geometric relationships and positions of the objects to be detected and the transmitter and receiver units, as well as the areas of shadow and obscuration as compared to the reflectivity and reflective area of the object the greater is the attenuation of the total received energy at the receiver.

Generally the more statesque the object is and the greater its dimensions in the Z plane, relative to it's horizontal surface area, the greater is its attenuating effect and hence the easier it is to detect. For any particular application of the

technique and relative dimensions of the objects to be detected should be considered and the positioning and spacing of the units should be controlled accordingly so that a sufficient attenuation of the received energy signal by virtue of the object's presence within the prescribed detection zone is ensured, thus maximising the probability of the object being detected.

The following are benefits of the present arrangement compared with conventional retroreflective techniques.

1) The object's colour or reflectivity is of very little practical significance. Only it's opacity at the operating wavelength of the detector is significant.

2) The detector is inherently sensitive to objects that can cast shadows. Thus objects with some element of height as depicted in Figure 1 for example are most suitable. This type of detector is ideally suited to detecting upright people for example.

3) The detector has inherently good discrimination capabilities between even relatively small objects and changes in background reflection caused by, for instance the movement of a floor mat or wetting of the floor by water, when compared with its retrolreflective counterparts.

Although the embodiment is described using near infra-red wavelengths, such as are provided by infra-red LED's, it will be readily appreciated by a

person skilled in the art that other wavelengths of light or even ultrasound and microwaves could readily be used.

By way of example only, a suitable signal processing system and detection system will now be described.

The detection circuit has been designed to provide the following features:

1) A means of avoiding interference between a number of similar detectors operating in close proximity to one another.

2) High immunity to interfering signals such as broad band infra-red emission from fluorescent lighting, mains hum, radio signals and intenses sunlight.

3) High immunity to changes in the effective sensitivity of silicon photo diodes due to high intensity ambient light.

4) High immunity against temperature drift or receivers and transmitters.

5) Automatic compensation for background reflectivity levels (self setting to site conditions).

6) Automatic adjustment to ongoing temporal variations in background reflectivity levels provided that these occur below a pre-set rate of change.

7) An automatically initiated rapid reset if detection of an object is continuous for greater than a predetermined period of time.

8) A means to initiate an audible or visual announcement prior to the reset action described in 7) above.

The circuit operation will now be described with reference to the schematic block diagram shown in Figure 2.

As a means to provide feature 1) above the circuit has a window comparator (50) which has its threshold voltages within a few hundred millivolts above and below 0 volts respectively. A signal derived from the mains voltage is AC coupled and low pass filtered at (52) to remove noise and then fed to the window comparator. The output of OR gate (54) is thus a short pulse occurring around the zero crossing points of the mains wave form. These pulses are fed to the reset inputs of both a binary counter (56) and octal counter (58). The binary counter (56) is clocked by a free running oscillator. The transmitter carrier frequency can be derived from the Q2 binary output of the counter (56) and the transmitter envelope signal rate may be chosen, for instance, to be one eighth of that frequency and so may be derived from the Q5 counter output. The output Q5 is then used to clock the octal counter (58). The outputs of the octal counter Q0 to Q7 inclusively mark sequential and equal time periods following each mains supply waveform zero crossing points. The octal counter output Q7 is connected to the clock inhibit input of

the octal counter and so the counter will only sequence once between each zero crossing.

The output Q0 in this example has been chosen to initiate a reference measurement via an analogue switch SW2, to be described further below. Thus any one of outputs Q1 through Q6 inclusively may be used to define a uniquely positioned carrier envelope by gating the selected output with the carrier frequency via an AND gate (60). In this way a number of similar systems may be operated in close proximity without mutual interference and without requiring an electrical connection between them. The only requirement is that their carrier envelopes are derived from different outputs on their respective octal counters. It can be seen that this arrangement provides six unique time windows within which transmission (and receiver measurements) may occur. The free running oscillator should have a broadly similar frequency.

As a means to provide feature 2) above immunity to interferring signals is achieved by the use of synchronous rectification. A synchronous rectifier (64) has a carrier input reference signal fed to it on line 66 as well as the amplified received signal on line 68. The output of the synchronous rectifier is thus a full wave synchronously rectified signal which is fed to analogue switches SW1 and SW2. Immunity is provided by the band width narrowing effect of the synchronous rectifier in conjunction with two low pass filters (70, 72). The low pass filter (70) outputs a DC level which is proportional to the amplitude of the received signal from the main

transmitter. The other low pass filter (72) which is connected to the output of an error amplifier (74) is used to provide both bandwidth narrowing of the received signal from the reference transmitter and also to provide some loop damping for the gain control loop. The function of this gain control loop will be described below.

As a means to provide feature 3) and 4) the receiver uses silicon photodiodes. Silicon photodiodes exhibit a change in effective sensitivity when subjected to high levels of background illumination such as may be caused by, for instance, sunlight or incandesent light. Generally the sentivity increases by a few percent but the actual level of change is dependent upon the intensity of the background light falling on the receiver. Since the detector measures small changes in received signals it is necessary to compensate for this change in receiver gain with a simple mechanism. The technique chosen here operates as follows:

The output of the synchronous rectifier (64) is time division de-multiplexed by SW1 and SW2. The signal de-multiplexed by SW2 is the signal generated by the reference transmitter (78), which has a direct light path to the receiver. The reference transmitter (78) is driven at a constant signal level. The signal from SW2 is compared with a reference voltage by an error amplifier (80). Negative feedback is applied via the low pass filter (72) to a gain control in the synchronous rectifier and so this control loop operates in such a way as to keep the signal at the output of the synchronous rectifier due to the

received reference transmitter signal substantially constant. The constant level is preset by the reference voltage on the error amplifier (80). In this way any changes in gain, e.g. an increase in gain, of the receiver are compensated for by a corresponding decrease in gain of the synchronous rectifier.

Thus the effective gain of the receiver circuit from the receiver all the way through to the output of the synchronous rectifier (64) is held constant. Therefore, any changes in the received signal level from the main transmitter must be due to changes in the actual received signal level at the receiver. This represents an inexpensive method of achieving accurate gain compensation.

An additional source of error in this kind of detector can be caused by changes in the ambient temperature causing variations in the transmitted power. Infra-red transmitters made from Gallium arsenide and Gallium aluminium arsenide have quite marked negative temperature co-efficients. The technique described above also provides compensation for these effects because the reference transmitter will exhibit a similar temperature characteristic to the main transmitters and so the appropriate receiver gain adjustment will be made automatically.

As a means to provide features 5) and 6) above the received and demodulated signal from the low pass filter (70) is fed to a subtractor (82). The output of the subtractor is a voltage representative of the received signal minus a variable offset

voltage. A comparator (84) indicates whether to increase or decrease the offset voltage. In this way the output of the subtractor (82) tends towards zero in the long term. Thus short term reductions in the received signal are detected by a comparator (86) provided that the reduction is greater than the threshold voltage presented to the comparator (non inverting input).

The output comparator (84) is connected to a bi-directional ramp generator (88) (integrator) and controls the ramp direction. For ease of description it will be assumed that comparator (84) is indicating that an increase in ramp voltage is required in order to bring the circuit into "balance".

Operation is as follows:

The ramp generator (88) ramps upwards towards a predefined limit which is set by the upper voltage threshold on a window comparator (90). If "balance" is not reached prior to the ramp voltage reaching the upper threshold then the window comparator (90) will trip causing,

1) SW3 to close providing hysteresis.

2) The ramp generator capacitor to be rapidly discharged until the ramp voltage falls below the upper threshold voltage of window comparator (90). The threshold is moved in response to step 1).

3) An 8 bit up/down counter (92) to increment its output count by one (N.B. ramp direction from comparator (84) indicates "up").

4) An 8 bit D to A converter (94) to increase its output voltage by one LSB.

5) A clock pulse to appear on the clock input of an octal counter (96).

The ramp voltage is attenuated and added to the D to A output in such a proportion that the total ramp voltage excursion from zero to the upper threshold voltage of window comparator (90) is made slightly greater than the voltage step in the D to A output produced by one LSB change in the D to A input. Given that the time required to discharge the ramp capacitor is very short compared to the ramp rate (of the order of 1:100), it can be seen that the output of a summation circuit (98) moves in essentially a ramp like manner. The finite resolution of the D to A converter acting in combination with the infinite resolution of the ramp generator provides an infinitely variable ramp voltage over an enormous range and at an accurately determinable rate of change. It would be virtually impossible to achieve this degree of performance over a wide temperature range with a capacitor based ramp generator alone and even if it were possible there would certainly be no cost or reliability benefit. The voltage tracking circuit described above has been operated over a +/- 8 volt ramp excusion range at 100 microvolts per second rate without resorting to any special circuit measures such as capacitor leakage compensation circuits etc.

Features 7 and 8 are provided as follows. When detection of a person in the zone (20) has occurred the output of the comparator (86) is high and circuit (100) operates to open the doors. The signal at the reset of octal counter (96) is low. The counter (96) thus cycles through its count cycle. Signals appear sequentially on outputs Q1 to Q7 every say 20 to 30 seconds. When an output appears at Q7 the bi-directional ramp generator (88) is caused to assume its rapid ramp mode. This results in the circuit resetting so that the door opening signal is removed. It will be seen that an audio generator (102) and a loudspeaker (104) are connected to the Q6 pin of the octal counter (96). This means that a given time, e.g. 20 second before the reset, i.e. when the counter output is cycled to Q6, the loudspeaker is energised to provide a warning or alarm that the doors are about to close.

In the arrangement shown in Figure 2 a door opening signal is produced by the circuit 100 when the input to the comparator (86) from the circuit (82) is above the threshold level applied to the comparator. To provide a facility which enables the sensitivity of the circuit to change with for example changes in floor reflectivity the circuit (98) can be replaced by a multiplier. Alternatively the threshold level of the comparator can be made variable the variation being in accordance with variations in the output level of filter (70). In figure 2B this is achieved by connecting the input of the circuit (82) via a resistor (106) to the junction of a potential divider (108, 110). This potential divider generates the threshold level for the comparator (86). The effect

of this connection is to provide a threshold level which varies with variations with the input to the circuit (82) and hence varies the threshold in accordance with changes in, for example, floor reflectivity. The ability of the circuit to adjust the sensitivity in this way is considered to be an important aspect of the control circuitry.

Figure 3 shows a modified form of the detection arrangement of Figure 1. In cases where the floor in the vicinity of the sliding doors is highly absorbent of infra-red energy it is more likely that the illuminated horizontal surfaces of the object being detected will cause a counter productive increase in reflected energy. In such circumstances there is a possibility that this could lead to an object not being detected. Figure 3 shows an arrangement in which the angular spread of both the transmitter and receiver beams is such that the intersection of the beams is arranged to occur at approximately 20 inches above the floor. It will be appreciated that, for example, a child of height 2 feet would be easily detected since its horizontal surfaces would be unable to directly reflect energy from the transmitter to the receiver. The shoulders of the child would be in a shadow cast by its head in the instance that the child's shoulders were parallel to the plane of the floor. It should be noted that the figure of 20 inches is given simply as an example and it may be that a different point of intersection would be more appropriate in other applications. Because of the modified geometry of the beams of Figure 3 the detection zone (20) is shorter than that of Figure 1, when viewed in the direction parallel to

the plane of the door. As the detector circuitry described above is designed to detect a predetermined percentage change in the receiver signal, the detector of Figure 3 will be more sensitive to a given object than that of Figure 1.

Historically optical detectors have been unable to detect reliably objects such as empty wire-framed shopping carts. Because the detection zone show in Figure 3 is more concentrated the detector is able more easily to detect such shopping carts. Experiments have shown that good results can be obtained when the detector circuit is set to detect percentage changes of the order of 5 to 10%. A further means of ensuring that all types of objects are detected is to arrange the circuitry to respond to both increases and decreases in signal level.

As explained in conjunction with Figure 1, in most installations there will be detection zones arranged on opposite sides of the door, so that objects lying directly in the path of the moving door and having a thickness greater than the perpendicular distance between the detection zones are detected. If the circuitry is designed to process signals from each detection zone independently then by looking at the relative timing of detection events in each zone it is possible to determine the direction of objects passing through the door. This can provide information which can be used to enhance operation of the door. For example, the redetection of a person by a motion sensor as he walks away from the door having passed through it could be eliminated by using the direction information. A further application could be in

estimating statistical parameters which may be of importance to management of the building in which the doors are used. The types of estimate that could be provided if all entrances and exits of the building are fitted with the device include the following:

1) Total number of people within a building with time.

2) Flow rates through the doors as a function of time.

The above description has been concerned principally with the use of the detector as a presence detector. It should be appreciated that the principles of the present detector can be used in motion detection. In motion detection changes in the received signal should ideally provide only momentary (of the order of one or two seconds) detection outputs sufficient to activate a door operating mechanism. This momentary detection can be provided by a simple high pass function as will be apparent to those skilled in the art. In the circuitry described above this can be achieved by increasing the voltage tracking rate by a suitable amount.

Furthermore, the range of the detector outwardly from the door needs to be increased to approximately 5 feet. This can be achieved by effectively tilting the detector away from the plane of the door. However, this may introduce variations in detection range under certain combinations of floor and clothing characteristics by virtue of the fact that reflection from the front vertical surface of an

object can now occur to a much greater extent. In other words reflection without obscuration has become possible by the change in geometric relationships.

An improved detection characteristic for motion sensing can be achieved by adopting the arrangement shown in Figure 3. The motion detection arrangement includes a transmitter (501) and a receiver (500) mounted as shown in Figure 3. It will be appreciated that these devices are additional to the transmitter and receiver arrangement which provide the presence detection. The transmitter (501) is configured to transmit two beams (506 and 507) to illuminate the floor in areas shown at (502 and 503). The receiver (500) is configured to receive energy along two beams (504 and 505) from the areas (502 and 503) respectively. The signals received by the receiver due to energy reflected from the areas (502 and 503) are measured separately to provide two signals L and R respectively. It should be noted that energy transmitted along beam (506) and received along beam (505) by way of reflection from an object must not corrupt the received signals. This condition can be achieved in a variety of ways including time division multiplexing or orthogonal modulation schemes. It will be seen that the received signal L is due exclusively to reflected energy from the transmitted beam (506) and in a similar manner the received signal R is due exclusively to reflected energy transmitted beam (507). Thus, it can be seen that the energy transferrence of transmitters to their respective receivers occurs almost exclusively by virtue of diffused reflection from the floor (that is to say as a result of an equal angle of incidence and

reflections). An object approaching the door is detected when it interrupts any one of the transmitter/receiver beams. This motion will be detected by change in the level of the signals received at the receivers. In the case of presence within the areas (502 or 503) the presence will again be detected as changes in the reflected signals. The control circuitry necessary for processing such signals can be based upon a modified form of the circuitry described in detail with reference to Figure 2 and such changes will be apparent to those skilled in the art.

It should be noted that the motion detection profile associated with the detector can be made adjustable to enhance the operation of the detector. For example, the door could be made solely responsive to a detector pattern shown schematically in Figure 4. Figure 4 is a plan schematic view of the door area showing the zone covered by the detector/transmitter arrangement. Figure 4 also shows the mirror image (dotted lines) about the centre of the door. The arrangement can be achieved by making the detector respond to changes in only signal R or signal L as appropriate. This can be achieved by means of a simple selection switch within the detector.

Another detection pattern is shown in Figure 4 and this can be achieved by responding only to a logical AND of the detection outputs due to the L and R signals or alternatively by a multiplication of signals representative of the signals L and R.

It should be noted that the detection pattern of the detector is dependent upon the height of the objects above the floor and the nature of this dependency can be controlled by the geometry of the transmitter and receiver beam cross sections and their directions. Detectors with very precise and desirable detection characteristics can be designed using the techniques described above.

Referring back to the presence detector described above, I have found that in some circumstances such a detector can be sensitive to wetting of the floor area in the operating zone of the detector. It is believed that this occurs because of strong specular reflections from the water surface and the floor. I have found that this problem can be alleviated or substantially eradicated if the transmitted and received beams are polarised in substantially orthogonal planes. Thus, I propose providing both the transmitter and receiver with a polariser which will plane polarise the radiation emitted by the transmitter and received by the receiver. The polarisers are arranged orthogonally so that, for example, the planar polarisation of the receiver polariser is at right angles to that of the transmitter. Any type of polariser can be employed, but a particularly suitable type has been found to be HR material as this has good performance in the near infra-red.

In the case of orthogonal polarisation, purely specular reflection is rejected and the effect on the received signal due to the presence of water is minimised to a level small enough so as not to be

detected. The automatic tracking facility provides sufficient compensation in this instance.

If the floor acts as a diffused reflector (which is true in most cases) the detector operates as has been described previously in that in most instances the presence of an object causes a signal drop. The fact that the detector circuitry is designed to detect a percentage drop in signal means that the sensitivity to a given object is not reduced by the attenuation produced by the exclusion of specular components from the floor or some of the background.

In some ways the detector response is improved in that the reflected signal from the floor is no longer dominated by the specular rich reflection components from the floor close the mid point between the transmitter and receiver units. This can result in a more even sensitivity profile along the length of the doorway.

It is believed that the use of polarisers in particular cross polarisers is novel in the general field of proximity detectors and its use therefore is not considered restricted to the particular type of proximity detector described in this application.

CLAIMS:

1. A proximity detector comprising a transmitter for transmitting a beam or beams of radiation into a preselected area of zone or zones, a receiver for receiving radiation from that zone, the transmitter and receiver being spaced apart and so located relative to said zone that the transmitter transmits a beam of radiation of predetermined shape into the area from where it is reflected into the receiver, the relative dispositions of the transmitter and receiver being such that when an object is present in the zone a shadow is effectively cast on either side of the object to thereby cause a fall in the level of reflected radiation receiver at the receiver.

2. A detector according to claim 1 including control circuitry responsive to the received signals for providing an actuator signal or signals for controlling the operation of apparatus such as automatically operable doors.

3. A detector according to claim 2, wherein the control circuitry is arranged to provide an actuating signal in response to the presence of an object.

4. A detector according to claim 2, or claim 3 wherein the control circuity is arranged to provide an actuating signal in response to the motion of an object.

5. A detector according to claim 2, wherein the control circuitry includes means for avoiding interference between a plurality of similar detectors operating in close proximity to each other.

6. A detector according to claim 2 or claim 5, wherein the control circuitry includes means for providing immunity to interferring signals such as extraneous radiation from fluorescent lighting, radio signals or mains hum.

7. A detector according to claim 2 or claims 5 or 6, wherein the detector includes photodiodes and the control circuitry includes means for compensating effective changes in the sensitivity of the photodiodes.

8. A detector according to claim 2 or any one of claims 5 to 7, wherein the control circuitry includes means for compensating for temperature drift of the receiver or transmitter.

9. A detector according to claim 2 or any one of claims 5 to 8, wherein the control circuitry includes means for providing automatic adjustment to compensate for changes in background reflectivity levels.

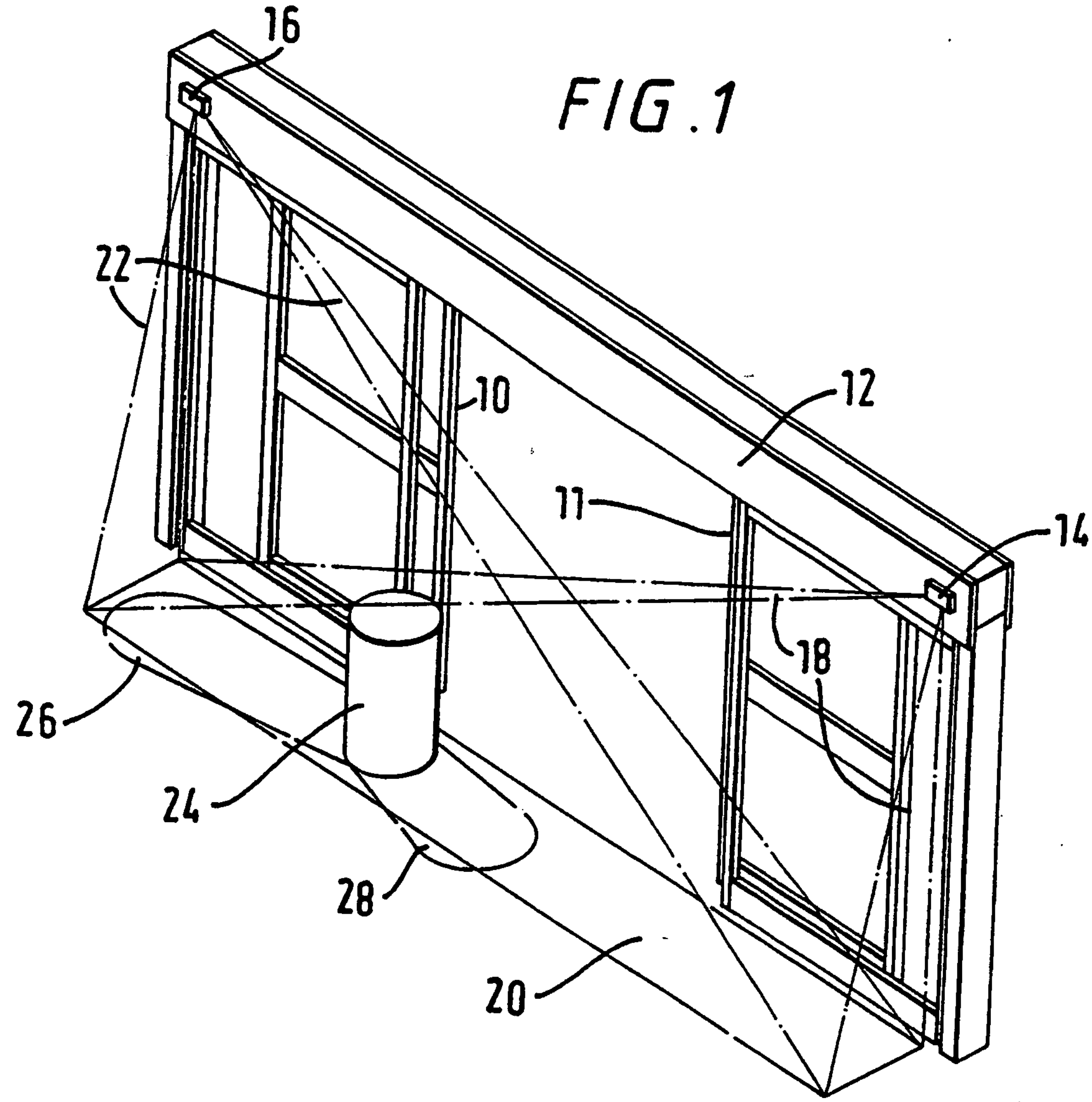
10. A detector according to claim 2 or any one of claims 5 to 9, wherein the control circuitry provides a rapid reset facility in the event that an object is detected as being present for greater than a predetermined period of time.

11. A detector according to claim 10, wherein the control circuitry includes means for providing an audible or visible alarm in the event that the object's presence for said predetermined time is detected.

12. A proximity detector of the type in which a transmitter transmits radiation into zone or zones and a receiver detects radiation receiver from the zone to provide actuating signals for actuating apparatus such as automatically operable doors, wherein a polarising means for polarising the radiation is associated with at least one of the transmitter and receiver.

13. A proximity detector according to claim 12, wherein a polarising means is associated with both the transmitter and receiver and said polarising means are arranged to function as a cross polariser.

FIG.1



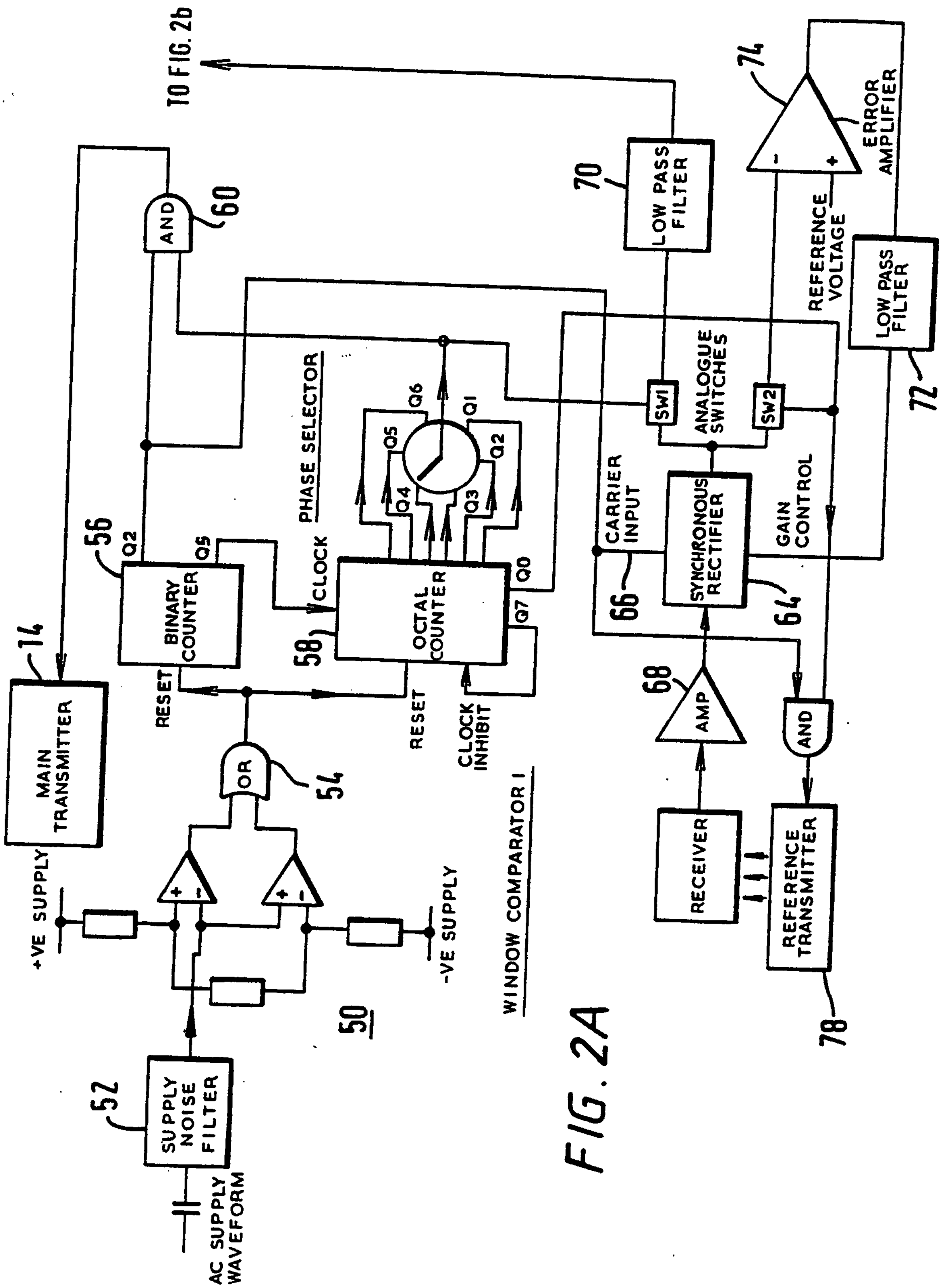

TO FIG. 2b
MAIN TRANSMITTER
14
BINARY COUNTER
56
Q2
Q5
RESET
AND
60
CLOCK
OCTAL COUNTER
58
Q0
Q1
Q2
Q3
Q4
Q5
Q6
Q7
RESET
CLOCK INHIBIT
PHASE SELECTOR
OR
54
+VE SUPPLY
-VE SUPPLY
SUPPLY NOISE FILTER
52
AC SUPPLY WAVEFORM
50
WINDOW COMPARATOR I
LOW PASS FILTER
70
ERROR AMPLIFIER
74
REFERENCE VOLTAGE
LOW PASS FILTER
72
SW1
SW2
ANALOGUE SWITCHES
CARRIER INPUT
66
SYNCHRONOUS RECTIFIER
64
GAIN CONTROL
AMP
68
AND
RECEIVER
REFERENCE TRANSMITTER
78

FIG. 2A

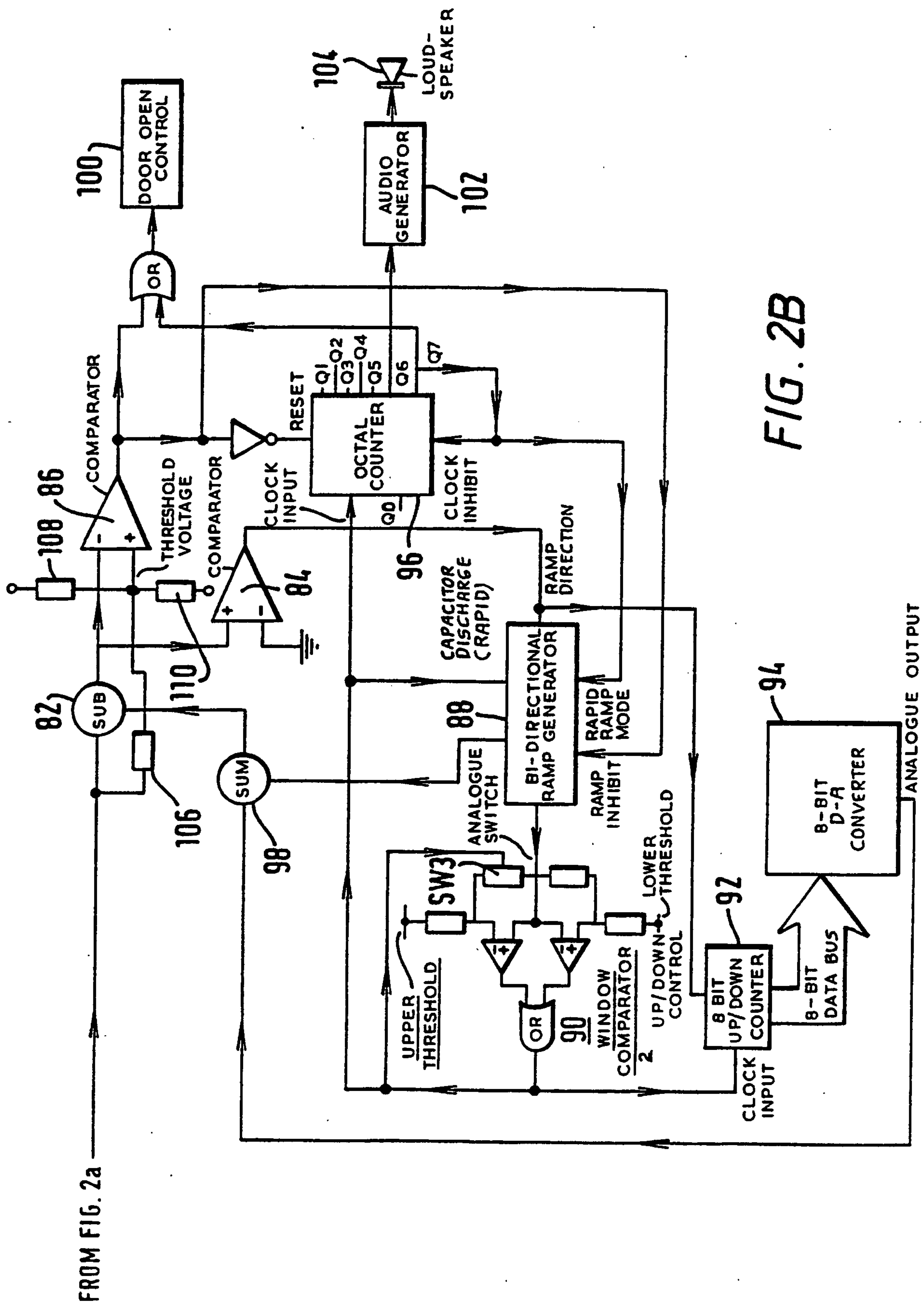
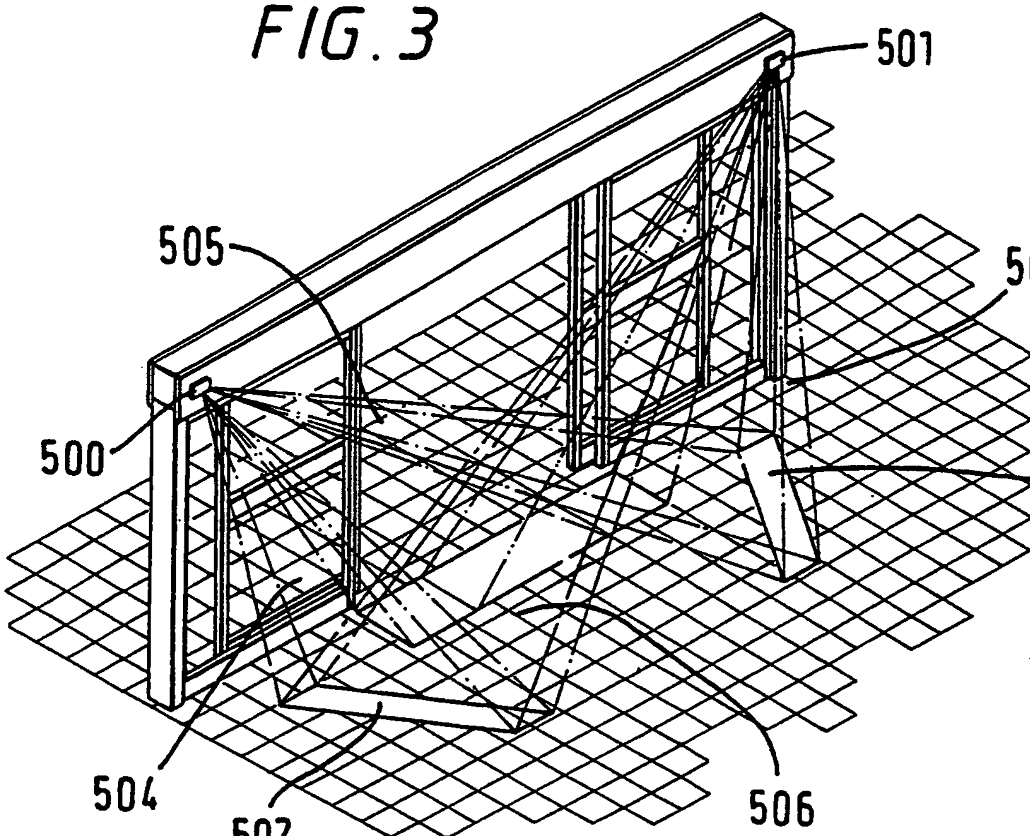

DOOR OPEN CONTROL
100
OR
AUDIO GENERATOR
102
104
LOUD-SPEAKER
COMPARATOR
86
108
THRESHOLD VOLTAGE
COMPARATOR
84
110
82
SUB
106
SUM
98
RESET
Q1
Q2
Q3
Q4
Q5
Q6
Q7
OCTAL COUNTER
CLOCK INPUT
Q0
CLOCK INHIBIT
96
CAPACITOR DISCHARGE (RAPID)
RAMP DIRECTION
88
BI-DIRECTIONAL RAMP GENERATOR
RAPID RAMP MODE
RAMP INHIBIT
ANALOGUE SWITCH
SW3
UPPER THRESHOLD
LOWER THRESHOLD
OR
90
WINDOW COMPARATOR 2
UP/DOWN CONTROL
8 BIT UP/DOWN COUNTER
92
CLOCK INPUT
8-BIT DATA BUS
8-BIT D-A CONVERTER
94
ANALOGUE OUTPUT
FROM FIG. 2a

FIG. 2B

FIG. 3



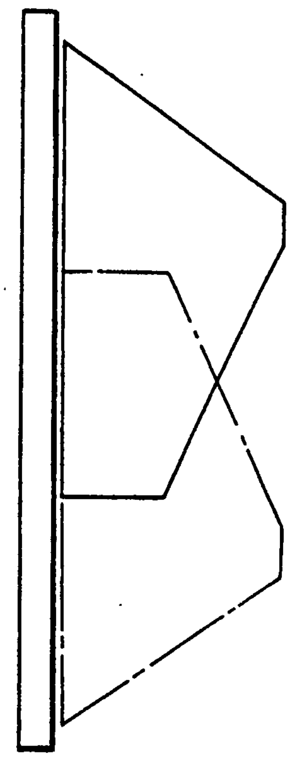
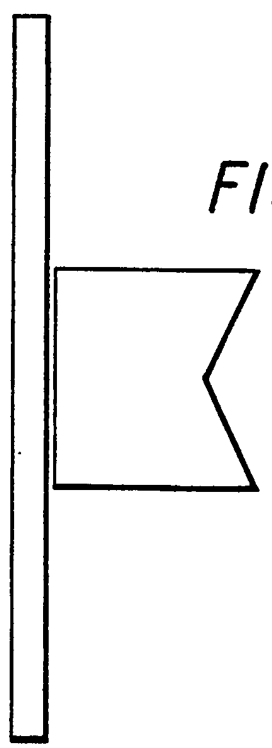


FIG. 4

FIG. 5



# INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 94/02188

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 6 G01V8/12

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01V G08B F16P G08G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | US,A,5 032 716 (LAM ET AL.) 16 July 1991<br>see abstract; figures 1,5<br>see column 1, line 21 - line 24<br>see column 1, line 54 - column 2, line 17<br>see column 2, line 66 - column 3, line 14<br>see column 3, line 27 - line 41<br>--- | 1-6,12, 13 |
| Y | PATENT ABSTRACTS OF JAPAN<br>vol. 9, no. 58 (P-341) (1781) 14 March 1985<br>& JP,A,59 193 382 (SOUGOU KEIBI HOSHIYOU K.K.) 1 November 1984<br>see abstract<br>--- | 1-6,12, 13 |
| Y | US,A,4 339 660 (BUCHHOLTZ ET AL.) 13 July 1982<br>see abstract; claims 1,2,4; figure<br>---<br>-/-- | 5,12,13 |

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

1

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 23 January 1995 | 10.02.95 |

| Name and mailing address of the ISA | Authorized officer |
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| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax (+31-70) 340-3016 | de Heering, P |

# INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/GB 94/02188

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | US,A,5 012 086 (BARNARD) 30 April 1991<br>see abstract<br>--- | 6 |
| A | US,A,4 973 837 (BRADBEER) 27 November 1990<br>----- | |

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Information on patent family members

International Application No
PCT/GB 94/02188

| Patent document cited in search report | Publication date | Patent family member(s) | | Publication date |
|---|---|---|---|---|
| US-A-5032716 | 16-07-91 | NONE | | |
| US-A-4339660 | 13-07-82 | NONE | | |
| US-A-5012086 | 30-04-91 | NONE | | |
| US-A-4973837 | 27-11-90 | AU-A- | 7802887 | 08-03-88 |
| | | WO-A- | 8801394 | 25-02-88 |